ScaRaB/Megha-Tropiques TOA Flux Computation at ISRO and Validation Efforts

V. SATHIYAMOORTHY
Atmospheric Sciences Division
AOSG/EPSA
Space Applications Centre, Indian Space Research Organization
Ahmedabad, India
<sathya@sac.isro.gov.in>

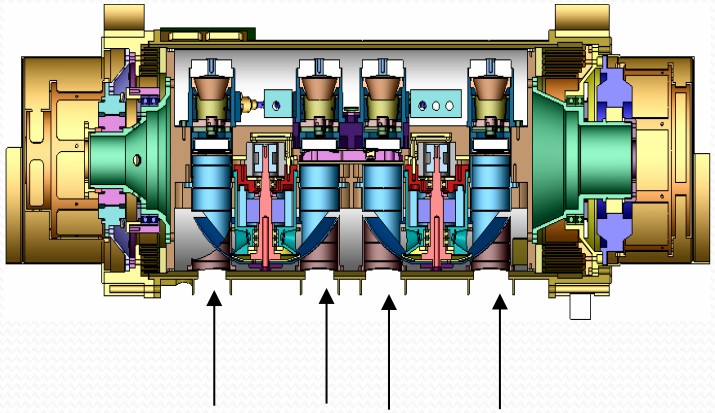
ScaRaB / Megha-Tropiques Mission

- Megha-Tropiques is a joint Indo-French satellite Project
- Launched from Sriharikota, India on 12 October 2011 by Indian PSLV-C18 rocket.
- Going to complete 3 years in orbit. 2 more years may be extended.
- Megha-Tropiques Level-1 data processing is done at ISSDC-DSN, Bangalore.
- Level-2 ScaRaB and SAPHIR processing are done separately at ISRO (Space Applications Centre, Ahmedabad) and CNES (ICARE).
- Validation of ISRO ScaRaB level-2 TOA Flux data are done at SAC, ISRO.
- Level-1 ScaRaB radiance data (Common for both ISRO and CNES) and Level-2 TOA flux data from ISRO are archived and disseminated through MOSDAC at Space Applications Centre, Ahmedabad.

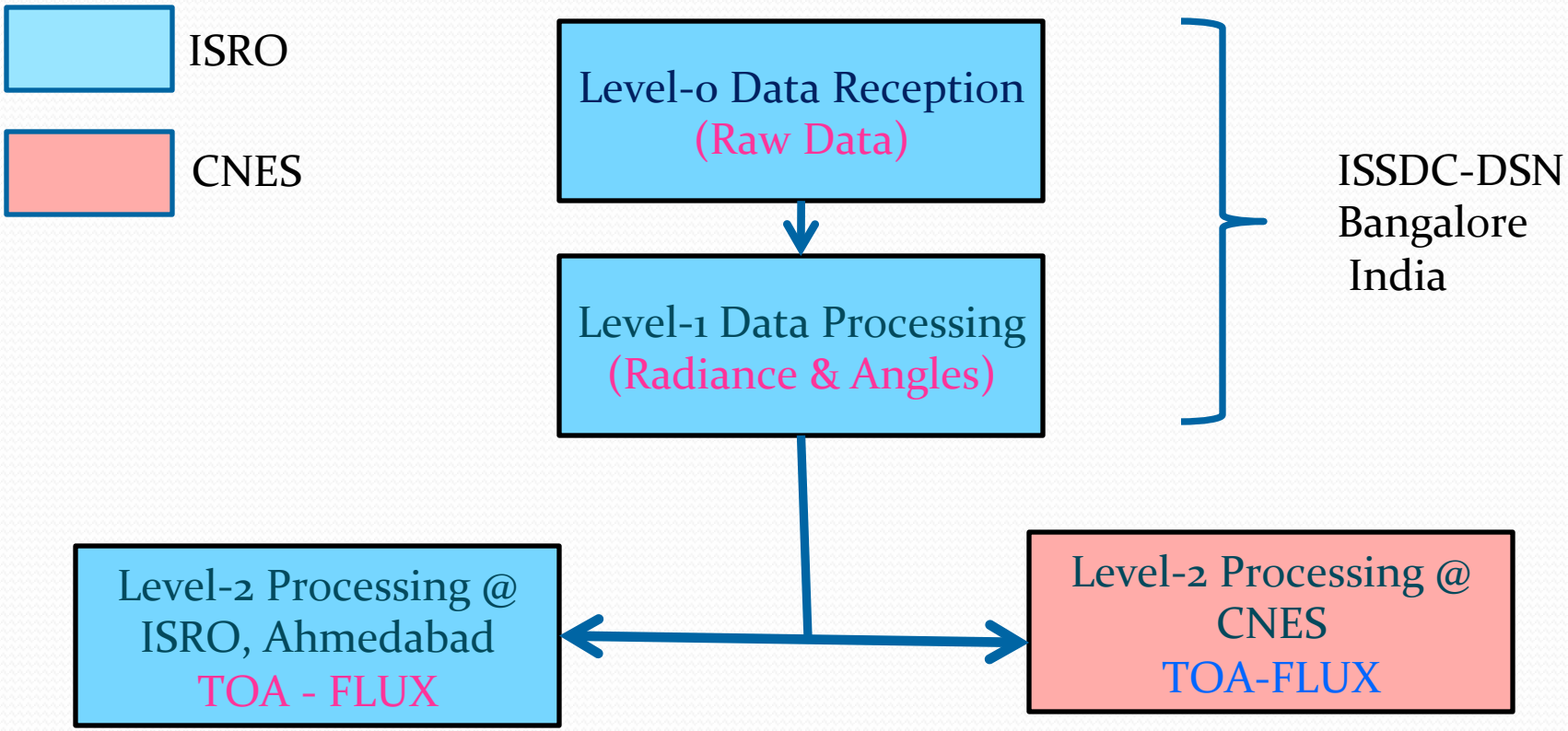
ScaRaB Channels

Channel	Description	Wavelength
SC1	Visible	0.5-0.7 µm
SC2	Solar	0.2-4.0 µm
SC3	Total	0.2-50.0 µm
SC4	IR Window	10.5-12.5 µm

Broad Band Channels



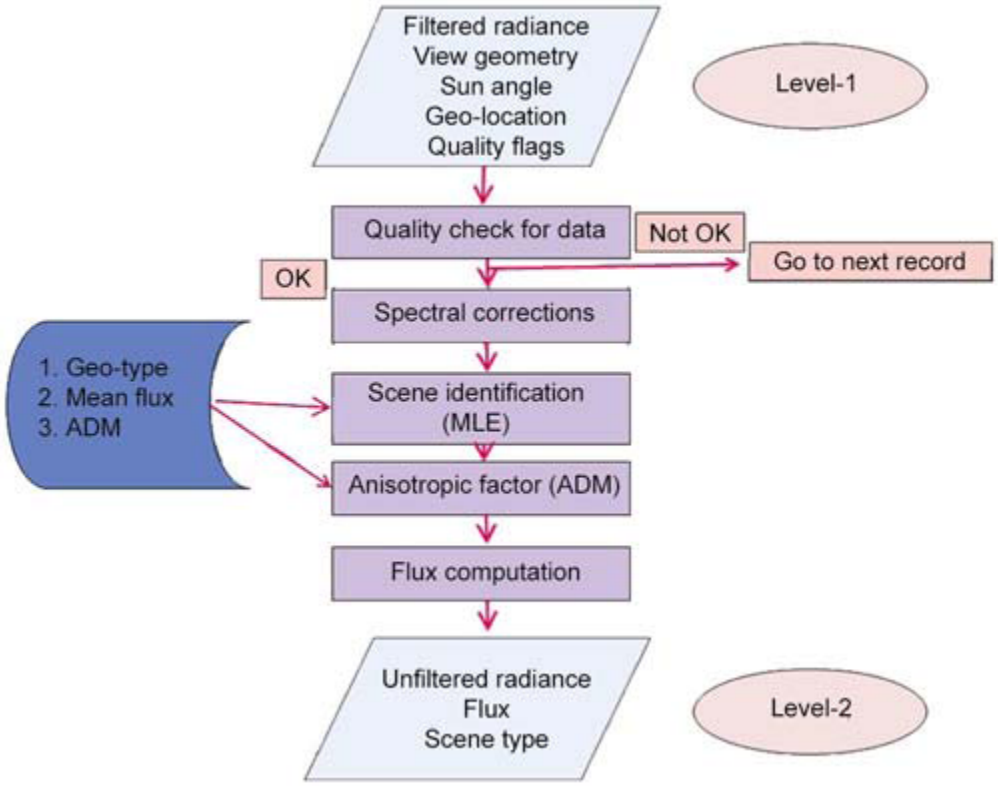
ScaRaB Data Processing Chain



LEVEL-2 TOA Flux Computation

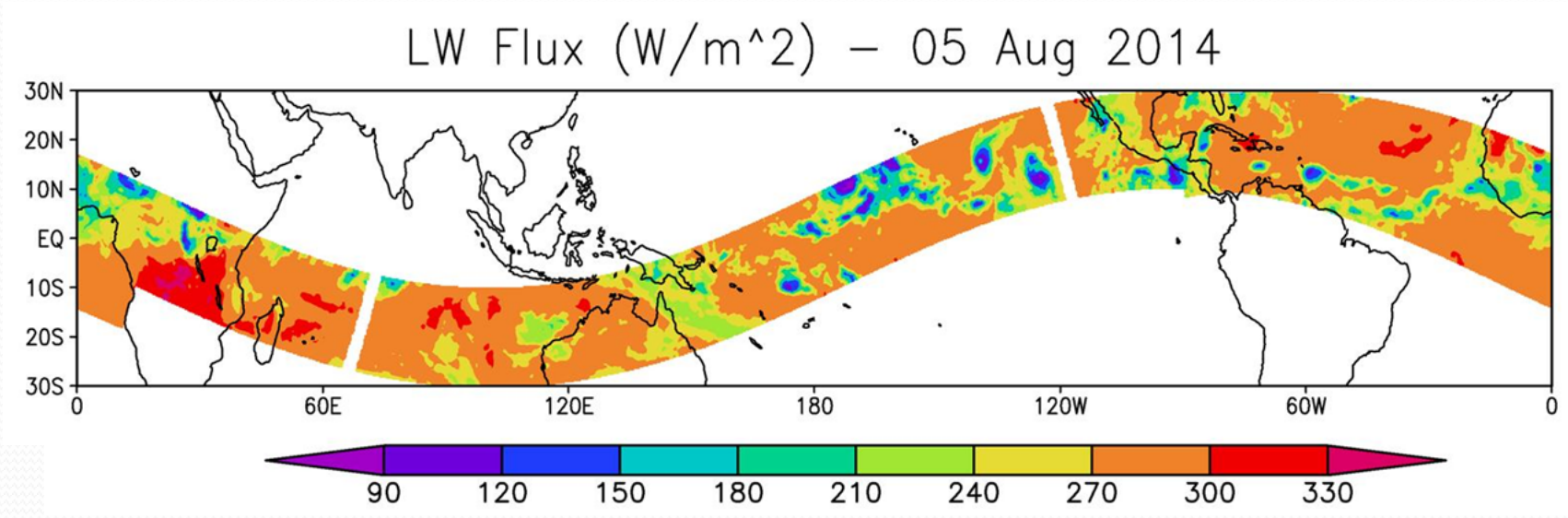
(ERBE Like Processing)

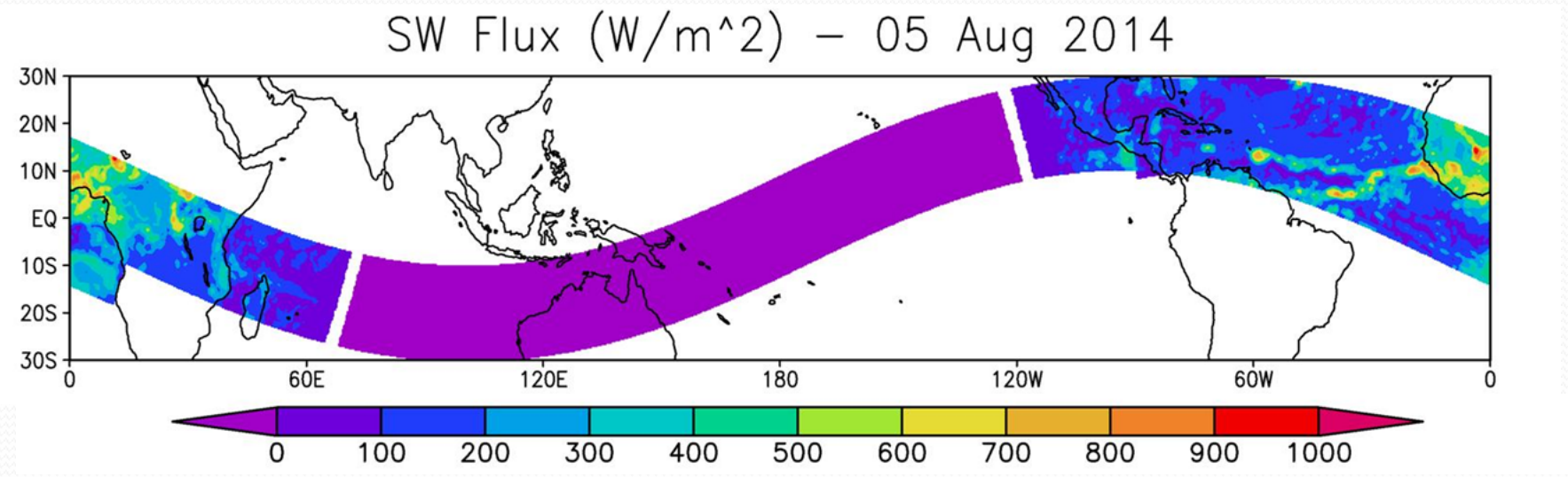
- ✓ ERBE-like Flux Computation algorithm is adopted for ScaRaB flux computation.
- ✓ Maximum Likelihood method is used for Scene Identification.
- ✓ 12-Scene classification – 5-Geoptypes and 4-Cloud types
- ✓ Raw radiances are corrected for spectral filtering effects
- ✓ Scene-type dependent angular correction models (Suttles et al, 1988, 1989) are used to deduce SW and LW fluxes at pixel as a function of radiance.
- ✓ This may be continuation of ERBE-like data available since 1985. Climate studies are possible.



ISRO Level-2 ScaRaB Flux are comparable with ES-8 product of CERES

Level-2 FOA Flux from ISRO

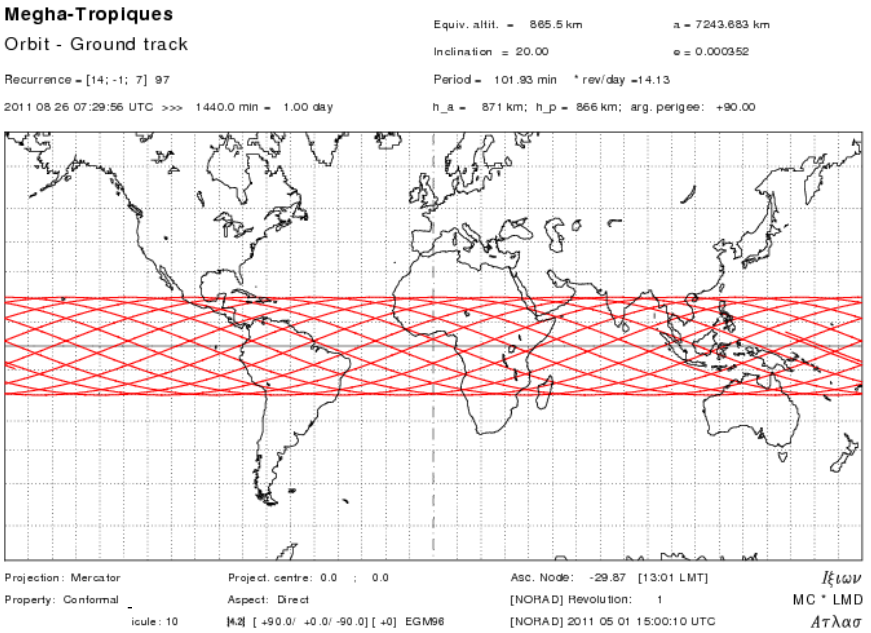


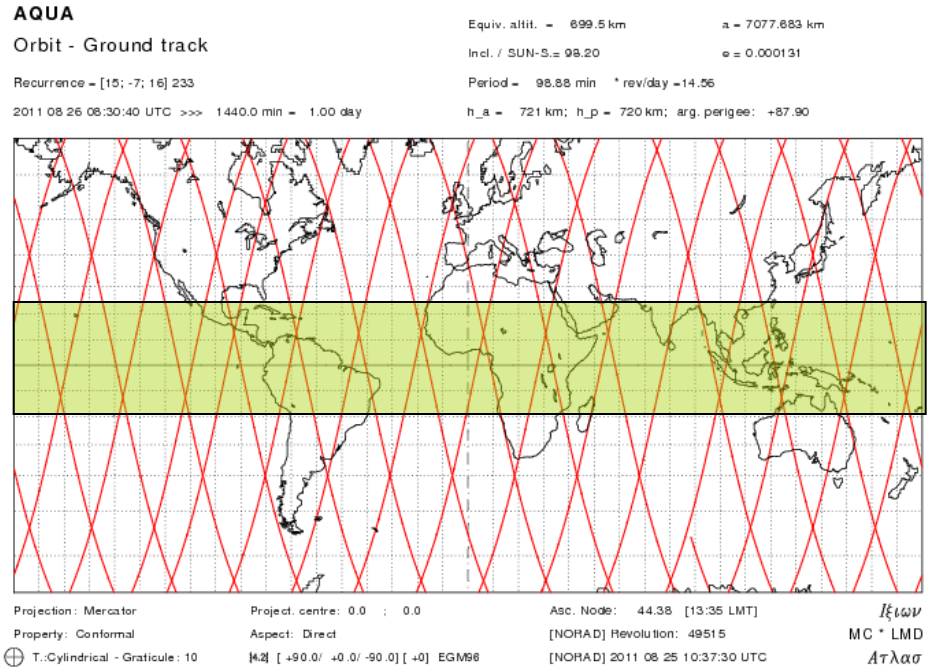


Cross-validation of ScaRaB Level-2 TOA Flux Data with CERES

ScaRaB/MT

One day coverage →





← **CERES/Aqua one day coverage**

ScaRaB and CERES Pixels

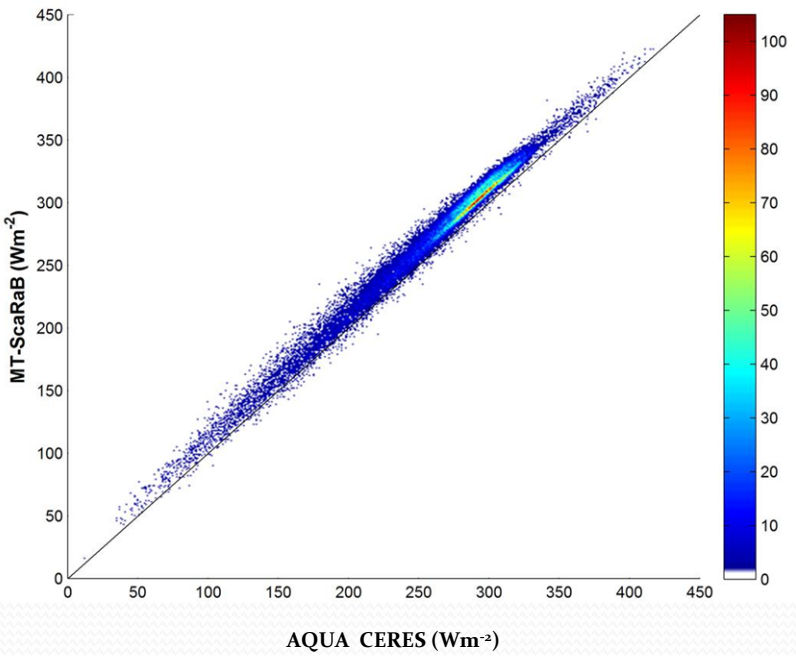
	CERES	ScaRaB
Resolution	20 km at nadir	40 km nadir
Scan Mode	Fixed Azimuth Plane Mode	Cross track
Orbit	Sun Synchronous Polar orbiter (1330 Hrs Equatorial Crossing time for Aqua)	Non Sun Synchronous orbit. 20° Inclination.
Version of Data compared	CERES Editon-1 CV ES8	Level-2 Version 1.06

Validation @ 2° lat. × 2° lon. Boxes and Half hour interval – Under sampling is avoided.

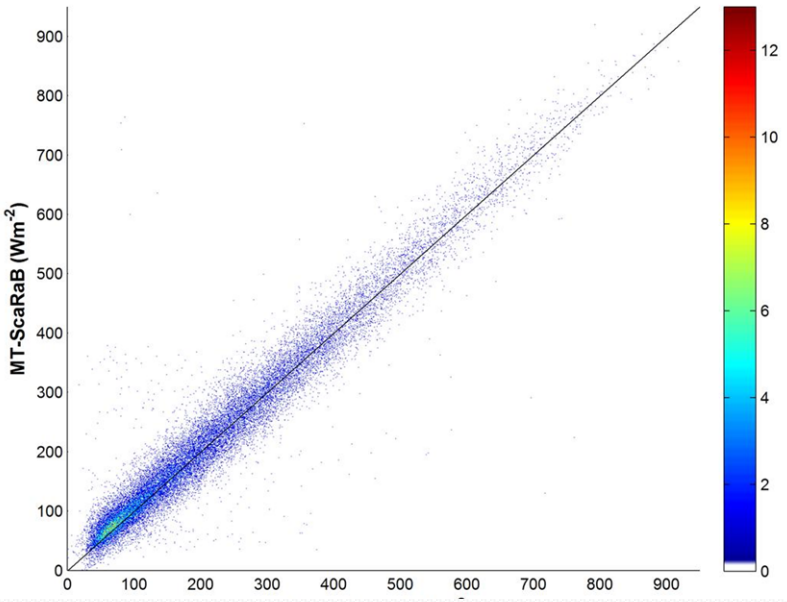
Under sampling is avoided.

All scenes, all angles, Day&Night.

Validation with only CERES onboard AQUA (10 Months –Mar-Dec 2013)



N=59,494
Bias = -2.1 Wm^{-2}
RMSE = 7.3 Wm^{-2}

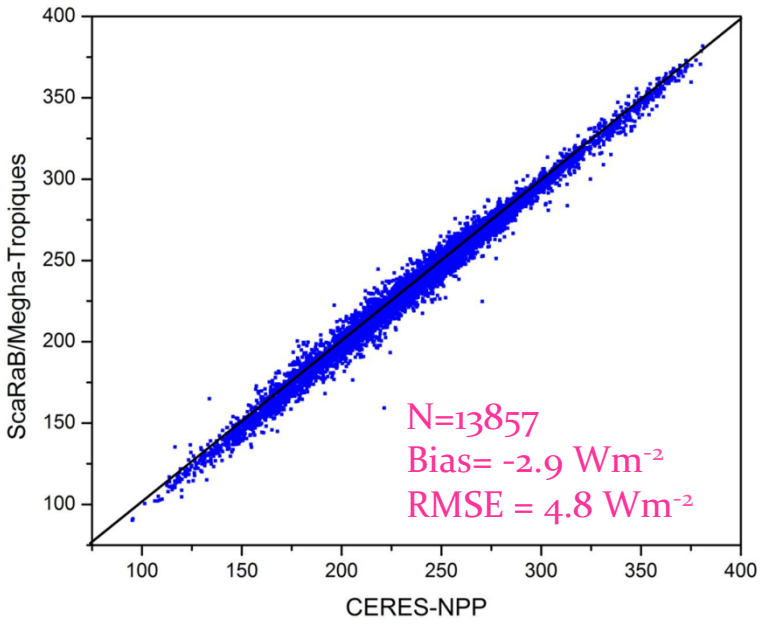


N=29,783
Bias = 13.6 Wm^{-2}
RMSE = 33.5 Wm^{-2}

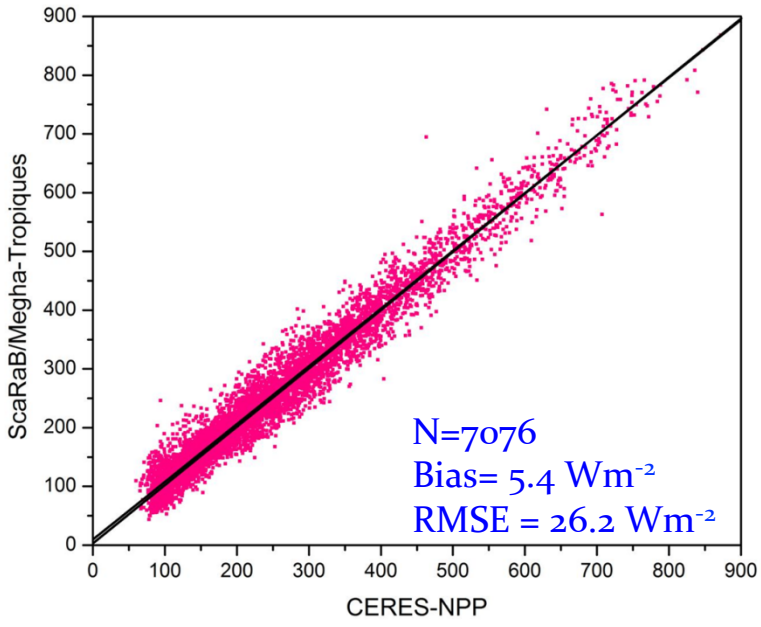
Validation with CERES onboard NPP (2 Months May-June 2014)

2 Months Data

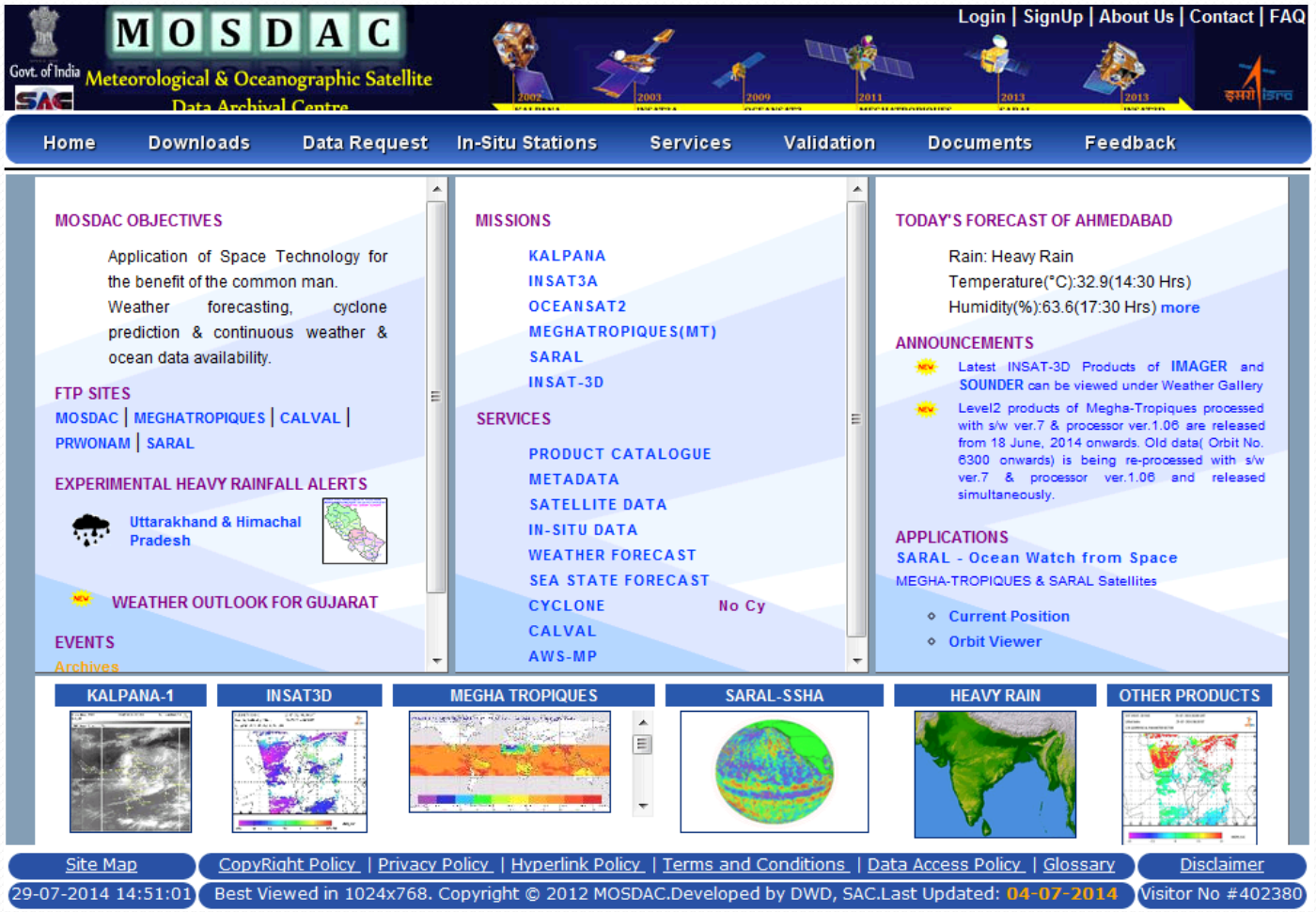
LW Flux Comparison



SW Flux Comparison



Meteorological & Oceanographic Satellite Data Archival Centre



Megha-Tropiques L1 and L2 data are available from MOSDAC.

http://www.mosdac.gov.in

CONCLUSIONS

ERBE-like processing is used to generate TOA Flux from ScaRaB/MT independently at ISRO, India. Data available from MOSDAC.

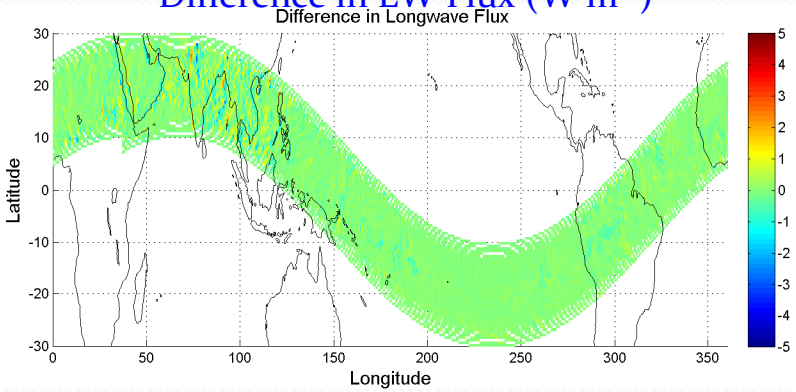
Validation efforts are going on to validate ISRO-ScaRaB data.

Future Plan: more rigorous validation with Edition 3 SSF data.

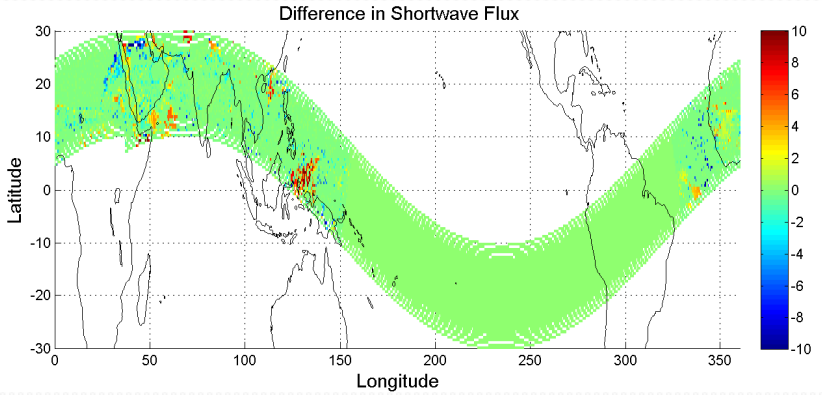
Comparison between ISRO & CNES Lev-2 Products

Orbit 14412-14413 28 July 2014 (Typical Monsoon Day)

Difference in LW Flux (W m^{-2})

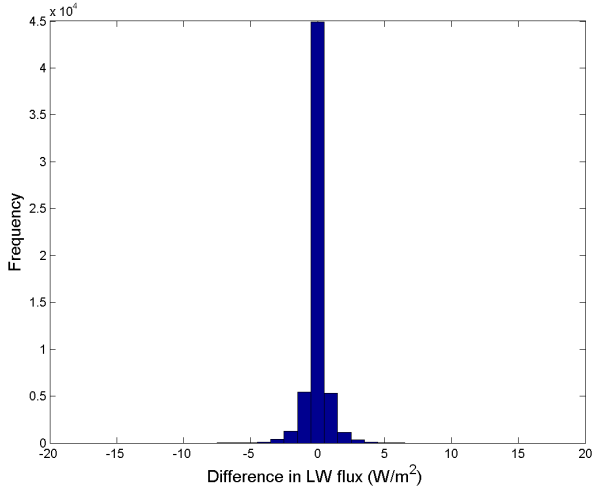


Difference in SW Flux (W m^{-2})

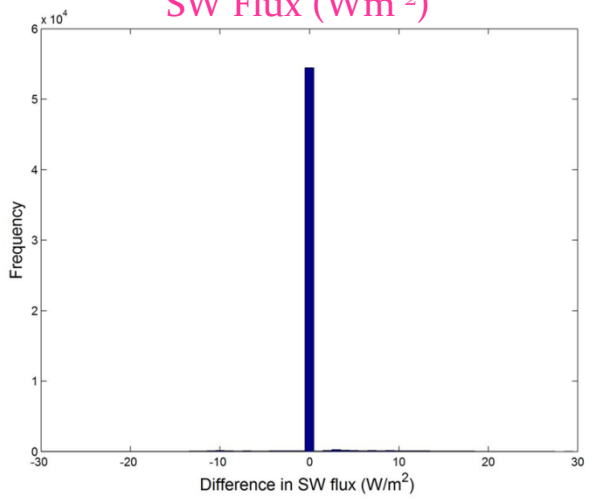


LW Flux (Wm^{-2})

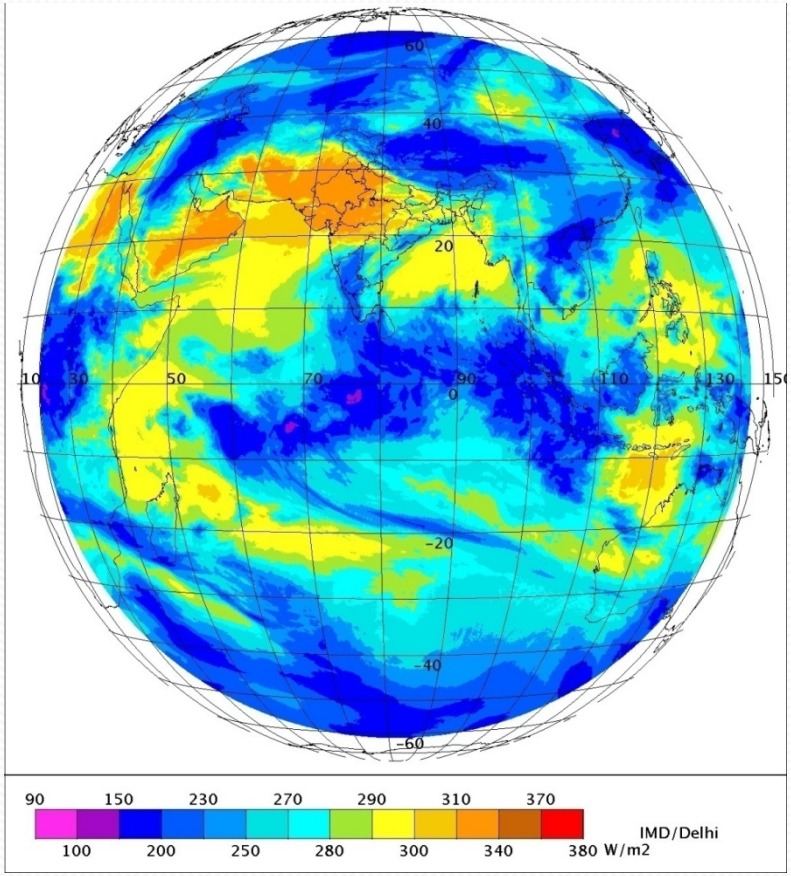
Histogram of the difference

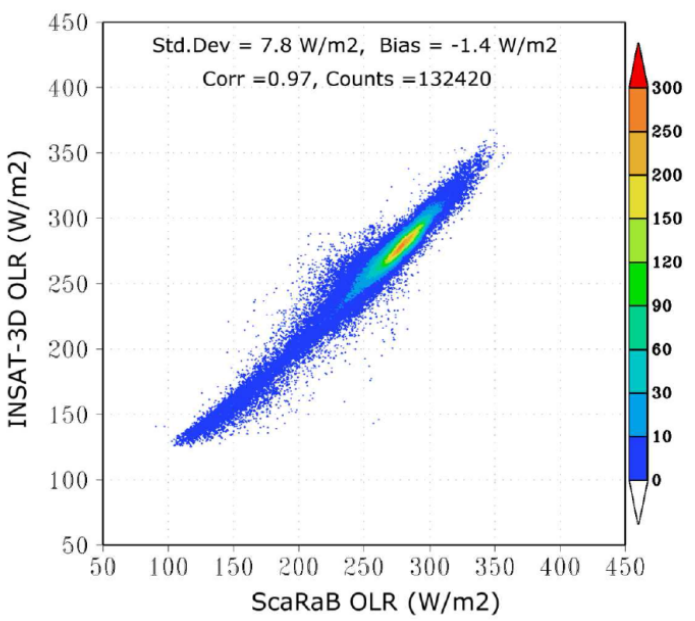


SW Flux (Wm^{-2})



Useful for validating narrowband INSAT-3D OLR data

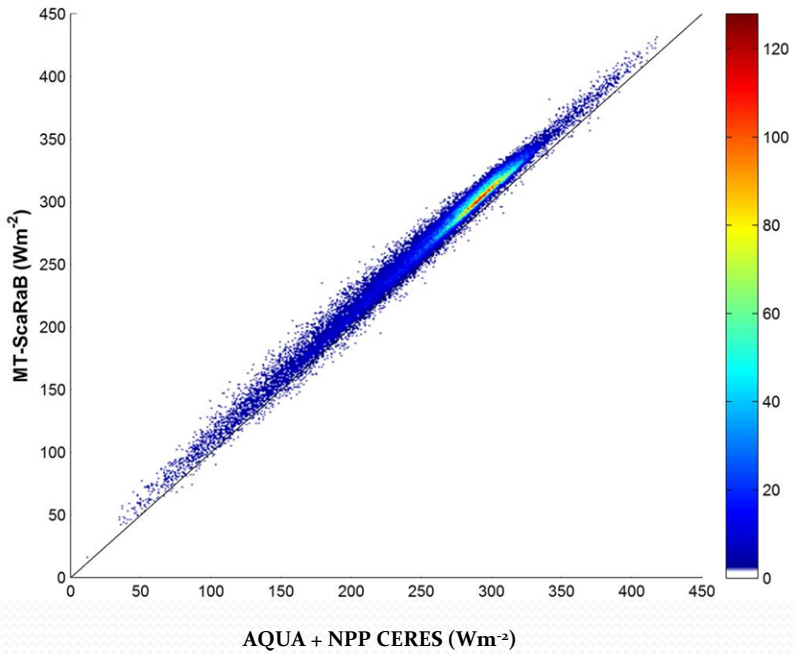




6 Channel imager & 19 Channel sounder

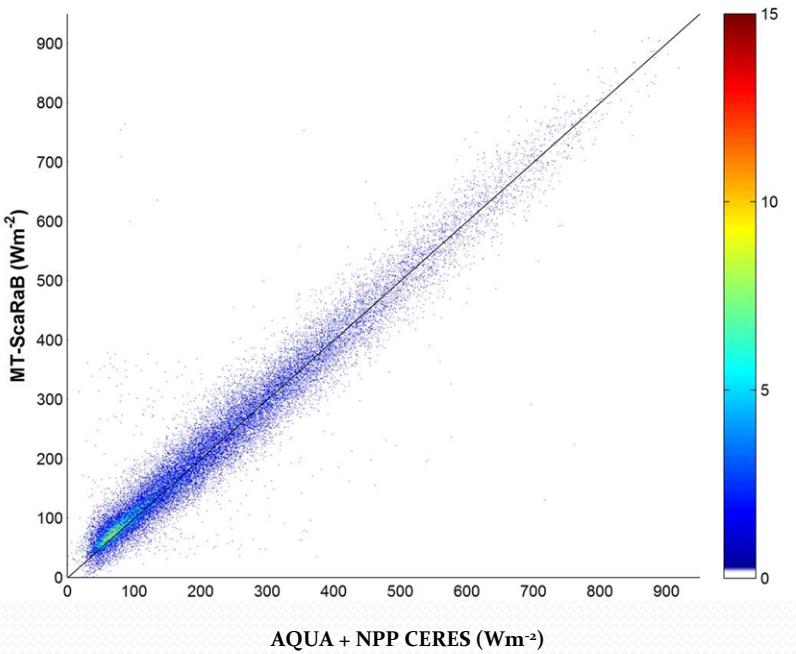
Validation for March 2013-Feb2014
CERES [AQUA+NPP]

LW Flux Comparison



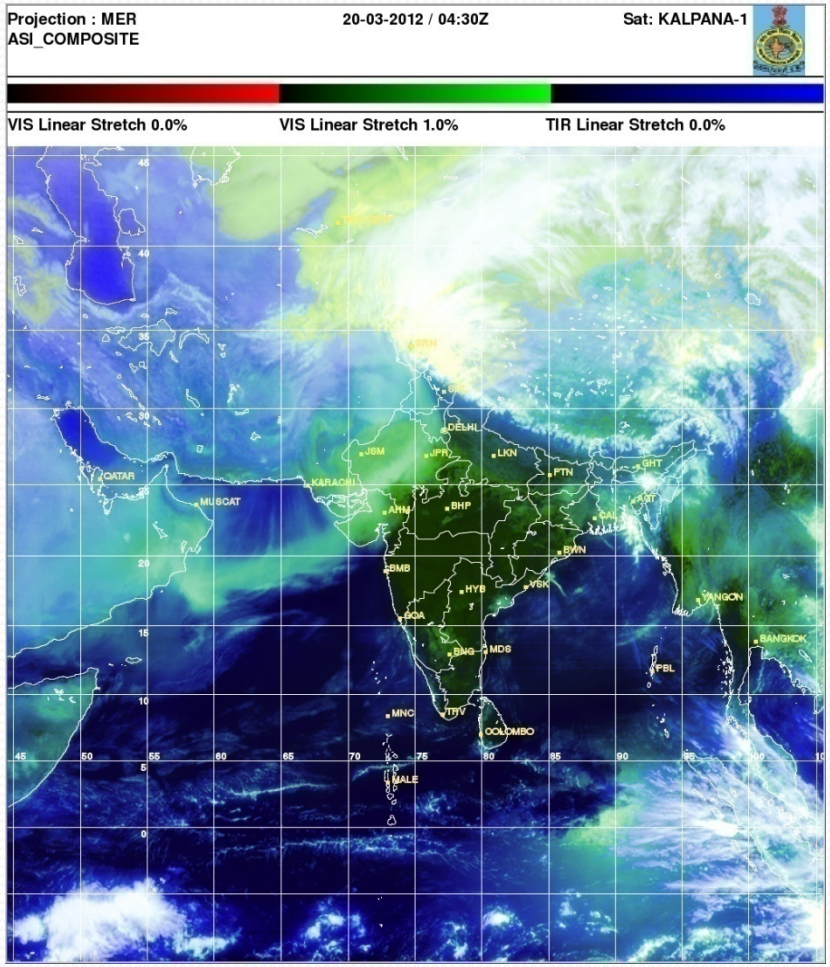
N=73,351
Bias= -2.3 Wm^{-2}
RMSE=6.9 Wm^{-2}

SW Flux Comparison



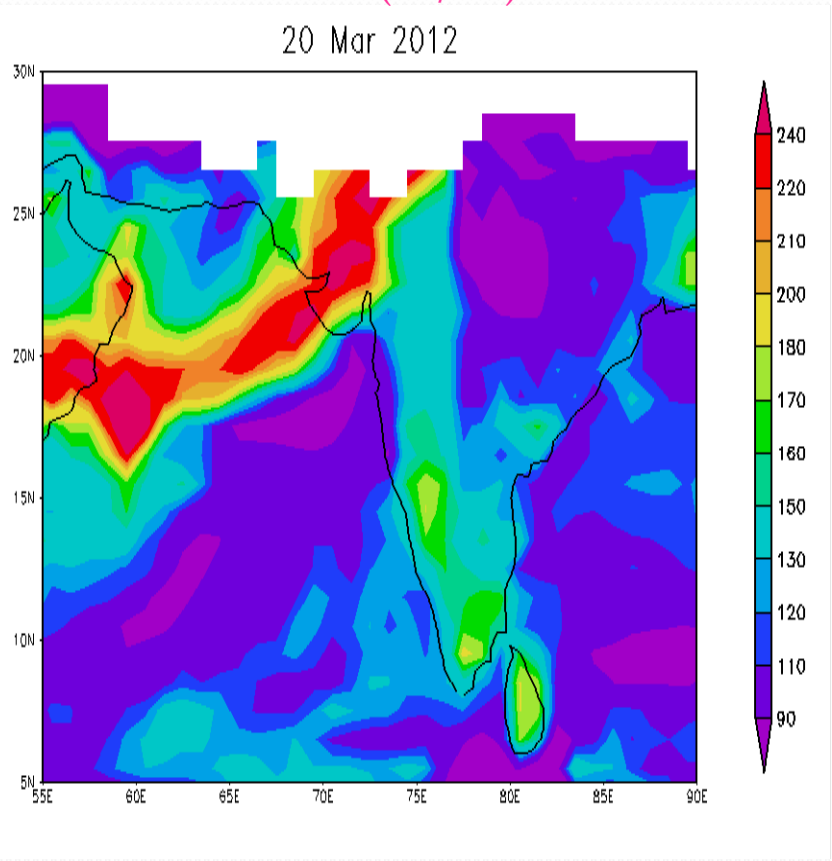
N=36,859
Bias= 12.0 Wm^{-2}
RMSE=32.2 Wm^{-2}

Potential of ERB data in understanding episodic meteorological events and Indian summer monsoon



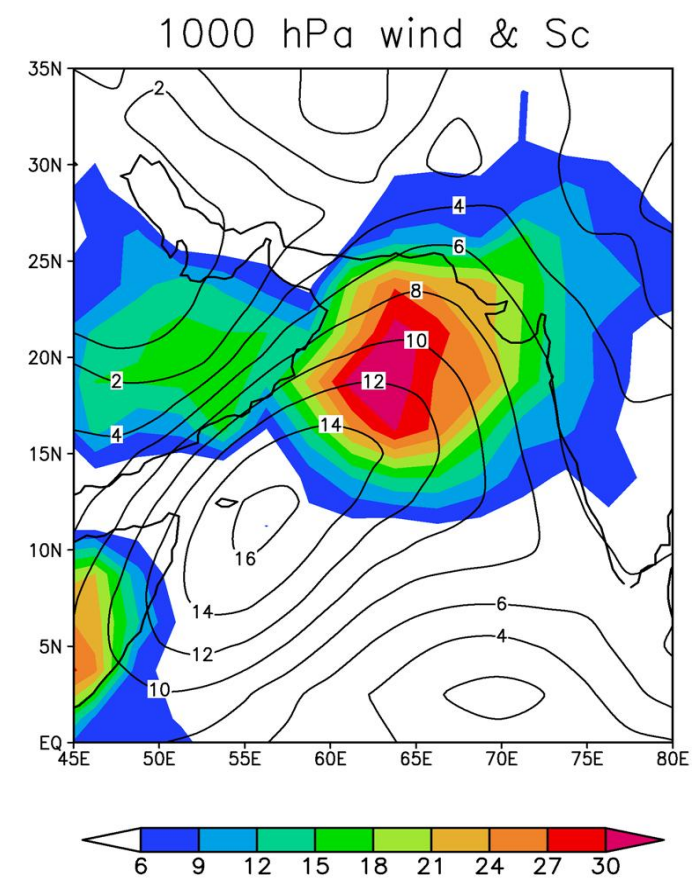
Kalpana-1 Color composite 20 March 2012

Reflected SW Flux (W/m²) from ScaRaB

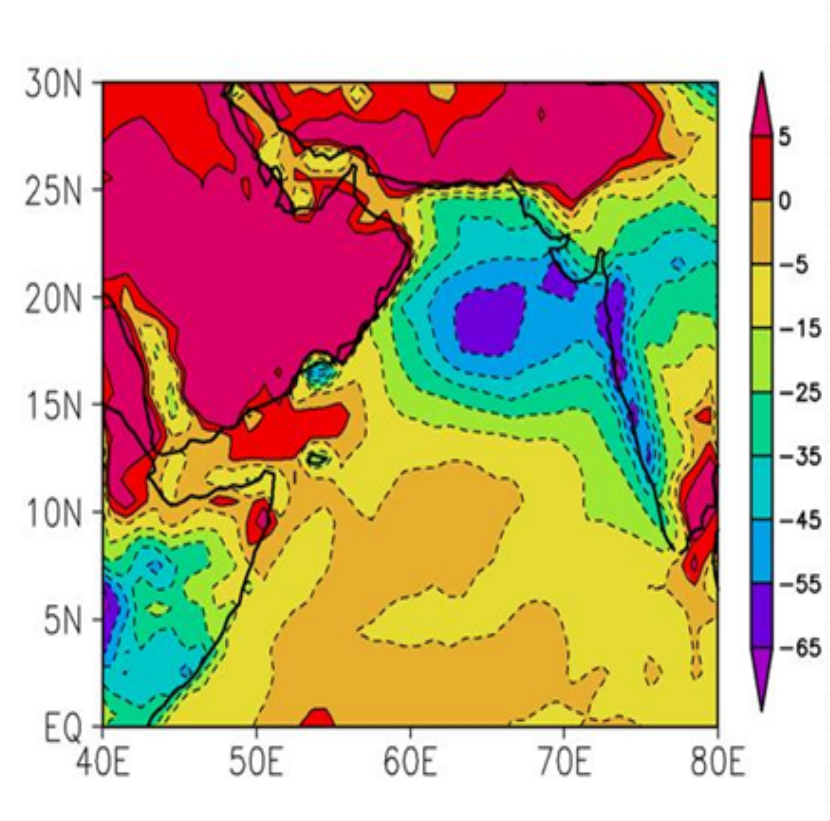


20 March 2012

Low Clouds over the Indian Summer monsoon region



Marine Stratus – Jul-Aug



NCRF (W/m2) – Jul-Aug

Sathiyamoorthy et al, 2013 – JGR-Atmosphere

SPECIAL SECTION: MEGHA-TROPIQUES

Top of atmosphere flux from the Megha-Tropiques ScaRaB

V. Sathiyamoorthy, Bipasha Paul Shukla, Rajesh Sikhakolli, Sasmita Chaurasia, Baby Simon, B. S. Gohil* and P. K. Pal

Atmospheric and Oceanic Sciences Group, Earth, Ocean, Atmosphere, Planetary Sciences and Applications Area, Space Applications Centre (ISRO), Ahmedabad 380 015, India

One of the important payloads on-board the joint Indo-French Megha-Tropiques satellite is the Scanner for Radiation Budget (ScaRaB). It is dedicated for monitoring the Earth Radiation Budget (ERB) parameters at Top of Atmosphere (TOA). In this article, details of the algorithm used for computing two important ERB components, namely TOA reflected shortwave and emitted longwave fluxes from ScaRaB radiance measurements are presented along with preliminary cross-satellite validation results.

orbit on 12 October 2011 using Indian Space Research Organisation's (ISRO) Polar Satellite Launch Vehicle (PSLV-C18). The main objective of the MT mission is to monitor the energy and water cycle components of the global tropics. MT has four sensors on-board, namely MADRAS (Microwave Analysis and Detection of Rain and Atmospheric Structures), SAPHIR (Sondeur Atmosphérique du Profil d'Humidité Intertropical par Radiométrie), ScaRaB (Scanner for Radiation Budget) and ROSA (Radio Occultation Sensor for Atmosphere).

Journal: Current Science
Special Issue on Megha-Tropiques.

Published on 25June2013

Table 1. Statistics of the preliminary validation of ScaRaB instantaneous top of atmosphere fluxes with CERES TOA fluxes on-board Aqua and Terra satellites for September–October 2012

Satellite	Parameter	RMSD (Wm^{-2})	Bias (Wm^{-2})	RMSD (bias-corrected; Wm^{-2})
Aqua	Longwave flux	5.3	–2.4	4.7
	Shortwave flux	30.5	16.1	25.9
Terra	Longwave flux	6.7	–4.2	5.3
	Shortwave flux	31.1	17.8	25.5

Joint CERES-GERB-ScaRaB workshop, 7-10 October 2014

Conclusions & Future Plans

- ERBE like algorithm is used to generate level-2 TOA fluxes from ScaRaB onboard Megha-Tropiques. The Level-2 processing is done at SAC, Ahmedabad.

- Quality of TOA fluxes are being monitored continuously with respect CERES onboard AQUA, Terra and NPP satellites.

- ScaRaB/Megha-Tropiques Flux data from ISRO better compares with CERES/NPP when compared to CERES/AQUA.

- ScaRaB data (both Level-1 radiances and Level-2 TOA Flux) are available from MOSDAC, SAC, Ahmedabad.

- Suitable diurnal interpolation methods will be used to derive monthly means of LW and SW fluxes.

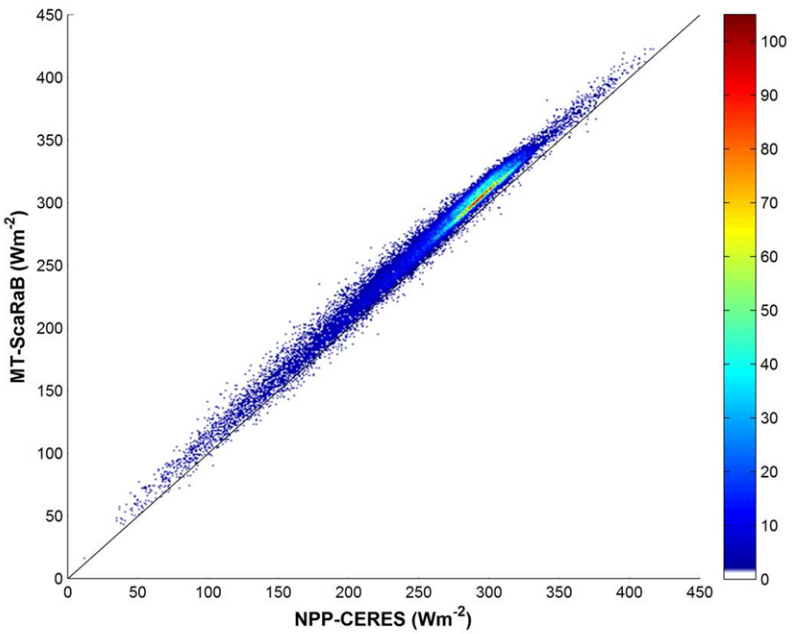
Backup Slides

Rsw=RFsw / SFF

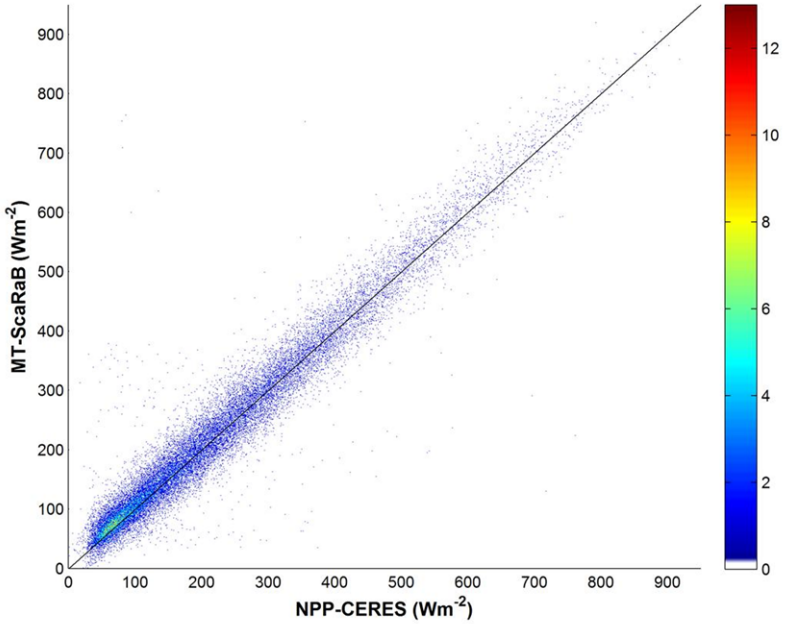
For Scenes 1 to 6 = 0.99
For Other Scenes = 1.0019

For Longwave No spectral Filtering is needed.

Validation with only CERES onboard AQUA (9 Months of Data)



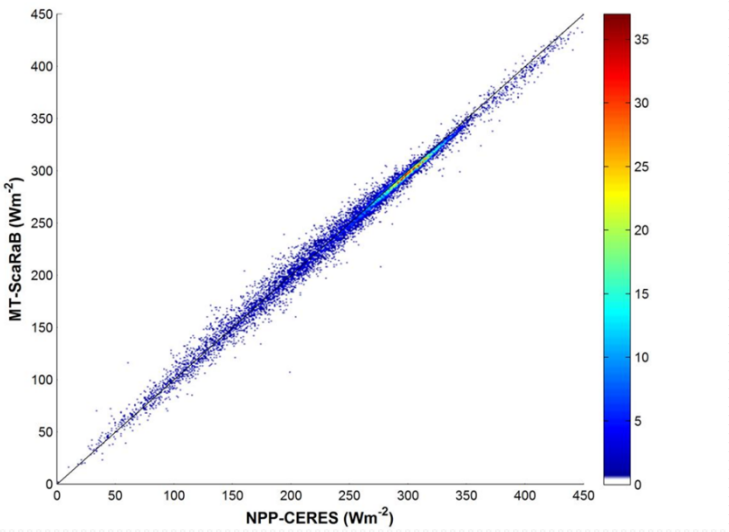
Bias = -2.1 Wm^{-2}
RMSE = 7.3 Wm^{-2}



Bias = 13.6 Wm^{-2}
RMSE = 33.5 Wm^{-2}

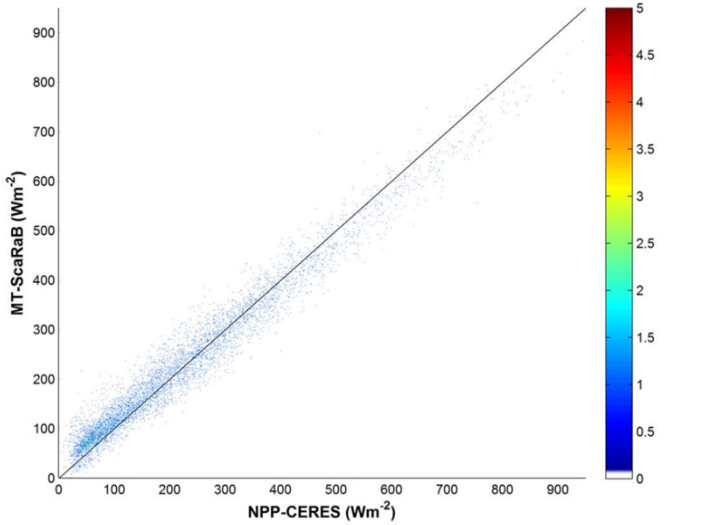
Validation Statistics for the latest version of the ScaRaB data from ISRO with CERES ES-8 Data onboard AQUA satellite.

LW Flux Comparison

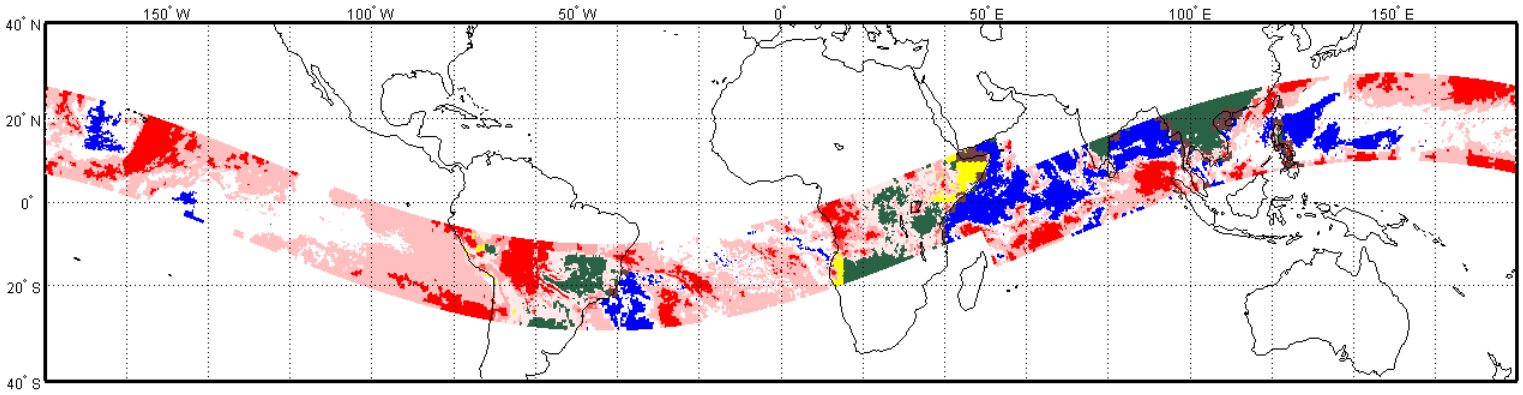


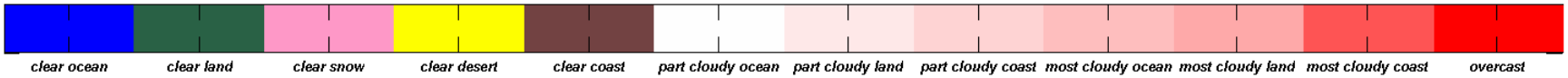
Bias= -2.9 Wm^{-2}
RMSE = 4.8 Wm^{-2}

SW Flux Comparison

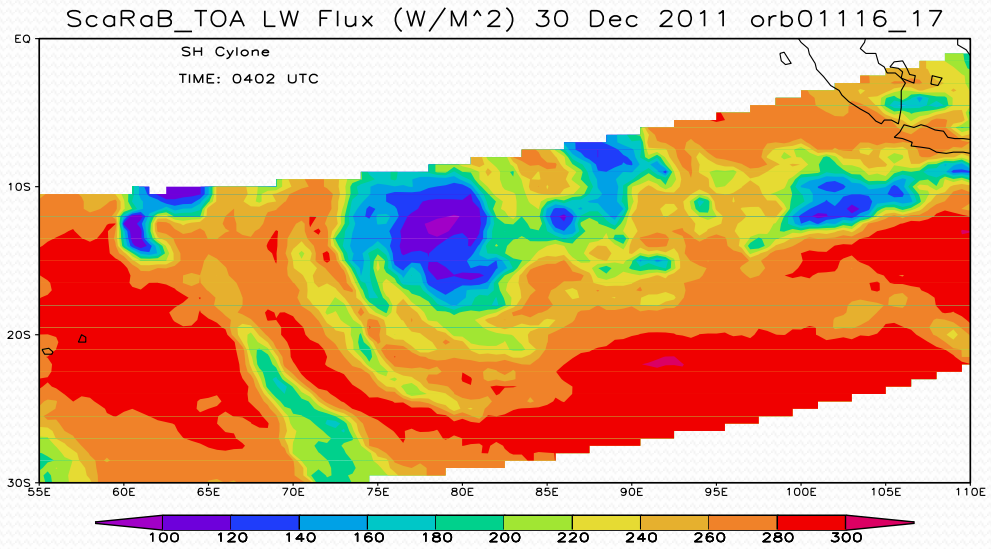


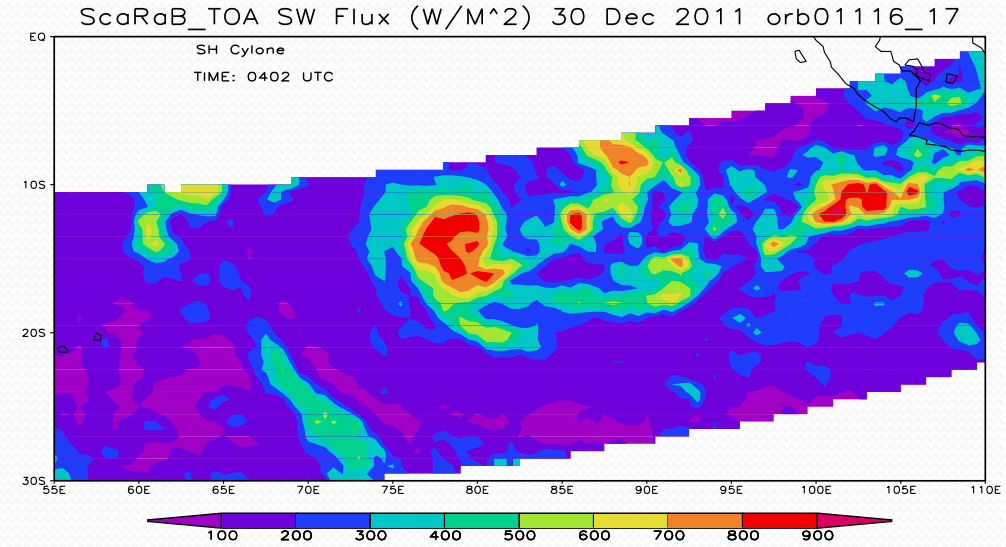
Bias= 5.4 Wm^{-2}
RMSE = 26.2 Wm^{-2}


150° W
100° W
50° W
0°
50° E
100° E
150° E
40° N
20° N
0°
20° S
40° S


clear ocean
clear land
clear snow
clear desert
clear coast
part cloudy ocean
part cloudy land
part cloudy coast
most cloudy ocean
most cloudy land
most cloudy coast
overcast

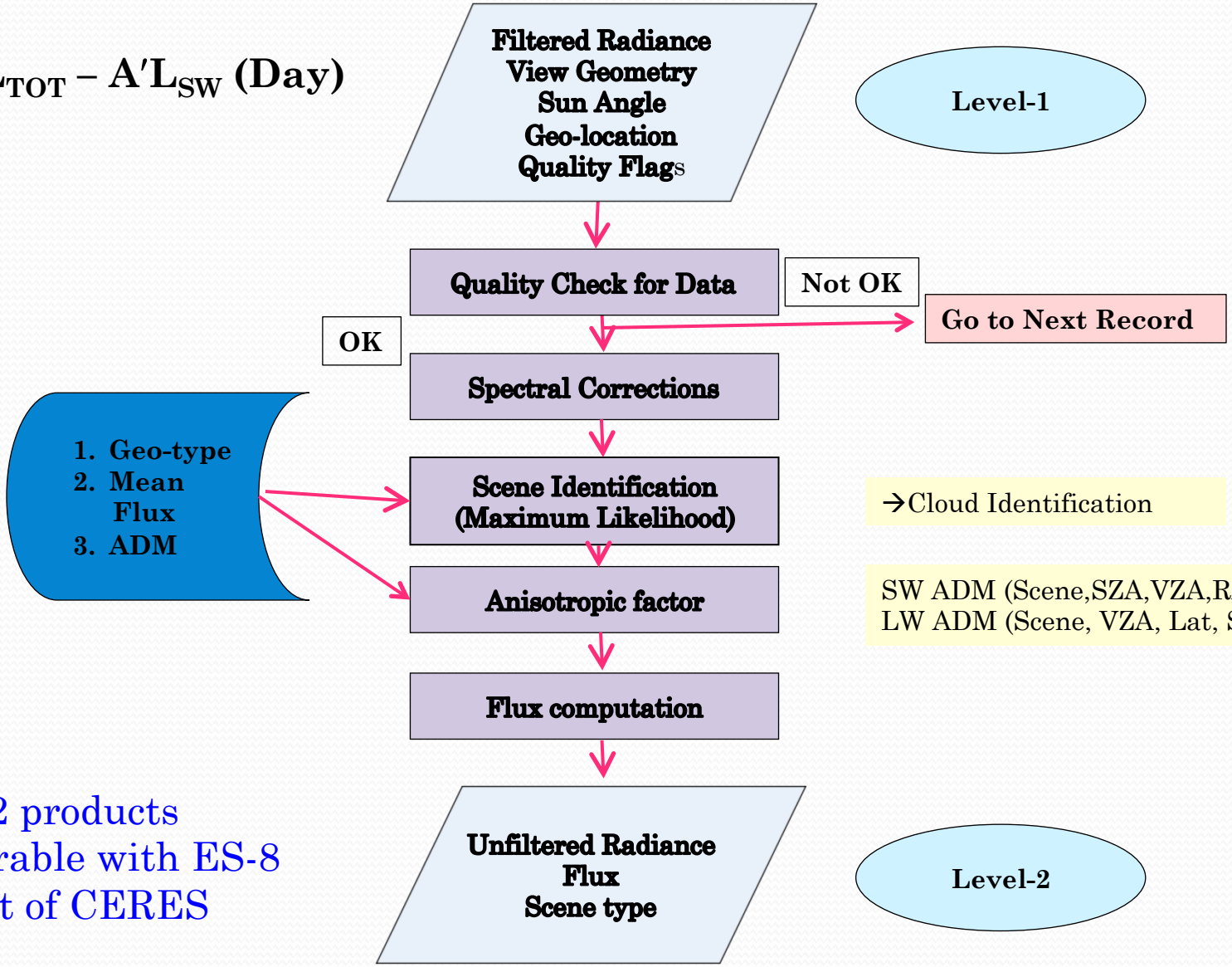
Southern Hemispheric Cyclone





Major Steps Involved in Level-2 Processing

$L_{LW} = L_{TOT} - A'L_{SW}$ (Day)



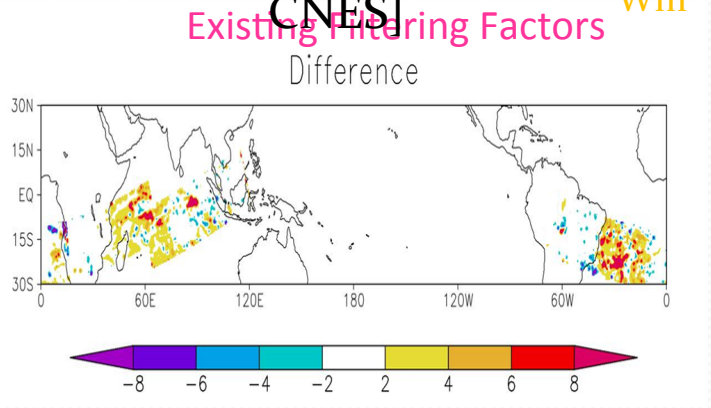
Level-2 products comparable with ES-8 product of CERES

ScaRaB Lev-2- Improvement

SW Flux Wm^{-2} [SAC – CNES]

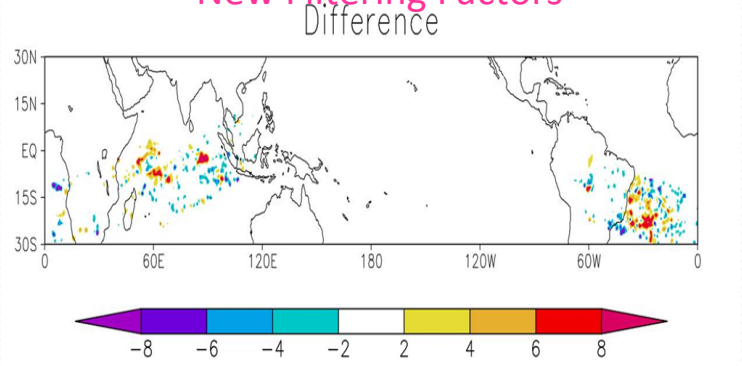
SD = 2.2 Wm^{-2}

Existing Filtering Factors



SD = 2.0 Wm^{-2}

New Filtering Factors



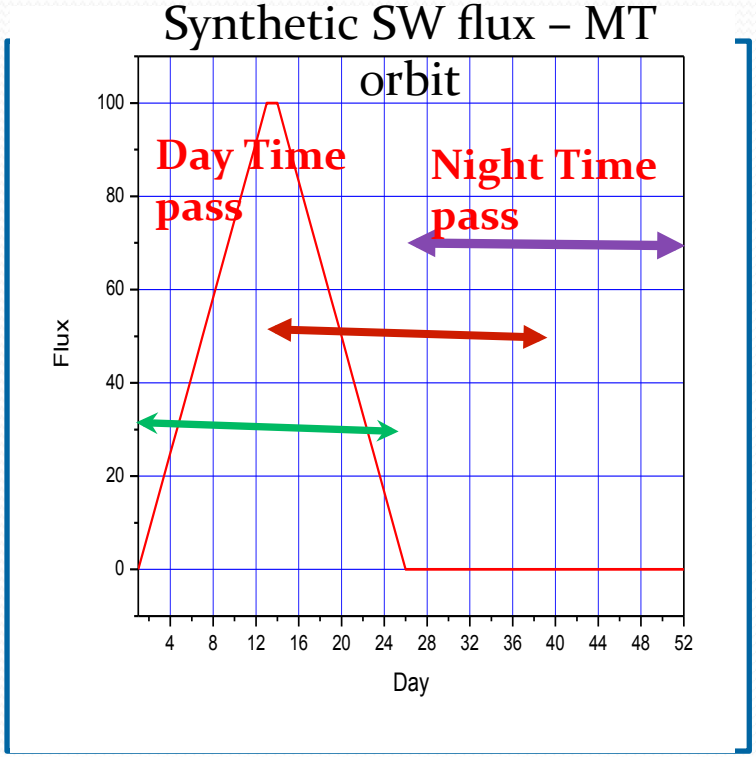
The filtered radiances may be slightly different from the unfiltered radiance when the spectra of the Earth scene and of the calibration source differ.

$$L_J = \int L_J(\lambda) d\lambda$$

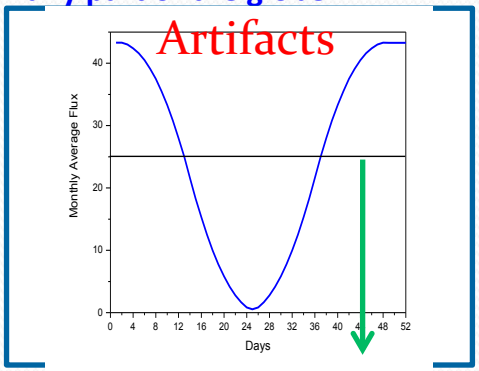
$$L_J^f = \int r(\lambda) L_J(\lambda) d\lambda$$

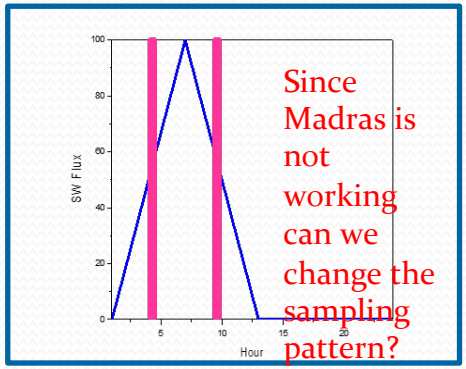
$$L_J = \frac{L_J^f}{F}$$

Feasibility - Lev-3 monthly averaging



MT takes 52 days to sample all hours of a day over a location. Hence in a month, MT samples part of the diurnal cycle over any part of the globe.





MT-related

Algorithm development - Level-3 ScaRaB Data generation

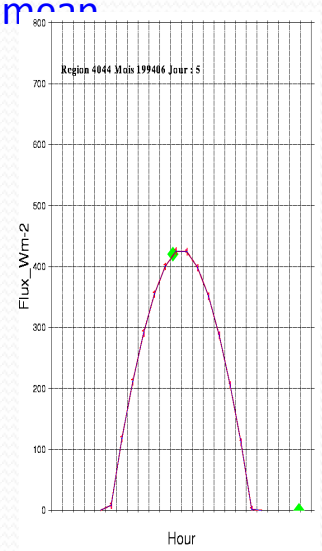
- Level-3 is monthly fluxes averaged over uniform grids

- Diurnal variation of incoming solar radiation is so pronounced that it is not a good assumption to generate monthly mean SW flux from 0 to 5 SW measurements taken at different local hours.

- In the SW domain, instantaneous flux measurements are interpolated or extrapolated in local time for the entire day following DIEP algorithm.

- In LW domain, a day-time half-sine fit over land, desert and coastal scenes are applied.

- Region by region, estimated local hourly fluxes are averaged to compute daily mean and ultimately monthly mean



This algorithm works well at least one observation per day is available during all days of a month. Else sampling artifacts may arise!

But we are ready with an algorithm.

INSAT-3D Products

PAYLOAD	Geo-Physical Parameters and Derived Products
IMAGER	Outgoing Long wave Radiation (OLR)
	Quantitative Precipitation Estimate (QPE)
	Atmospheric Motion Vector (AMV)
	Upper Troposphere Humidity (UTH)
	Sea Surface Temperature (SST)
	Land Surface Temperature (LST)
	Water Vapor Wind Vector
	Insolation
	Snow Cover
	Fog, Forest Fire, Smoke and Aerosol Identification
	Tropical Cyclone Position and Intensity Estimation
SOUNDER	Temperature, Humidity profiles and Integrated Ozone
	Geo-potential Height (GH)
	Layer Precipitable Water
	Total Precipitable Water
	Lifted Index (LI)
	Wind Index (WI)
	Dry Microburst Index (DMI)
	Potential Temperature Differential
	Ozone estimate